DIAGNOSTICS DURING THE ALBA BOOSTER COMMISSIONING

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Abstract

The ALBA Booster is a synchrotron designed to accelerate electron beams from 100 MeV to 3GeV in a 3Hz cycle. The maximum pulse coming from the ALBA Linac provides 5 mA in the Booster. In order to check all the Booster sub-systems, a Booster pre-commissioning took place during two weeks in January 2010. This paper presents the Diagnostics elements installed in the ALBA Booster and our experience during the Booster pre-commissioning.

INTRODUCTION

The ALBA Booster installation finished in November 2009. In order to find out unexpected problems at an early stage, a short Booster pre-commissioning was scheduled for January 2010. It lasted only two weeks so as not to interfere excessively with the installation of the Storage Ring and beamlines.

The electron beam at the Booster comes from the Linac, which can work in Single and Multi Bunch Mode and was commissioned in Autumn 2008 [1]. The maximum Linac pulse charge is 4 nC, which represents a current of 5 mA at the Booster. The beam is then accelerated in the Booster synchrotron from 100 MeV to 3 GeV in a 3Hz cycle. The Booster consists of a 4-fold symmetry FODO lattice with 40 combined function dipoles [2]. The basic parameters of the ALBA Booster are listed in Table 1.

Table 1: Booster design main parameters.

Parameter	Injection	Extraction
energy, E [GeV]	0.1	3.0
hor emittance, ε_x [nm-rad]	150	9
max. current, I [mA]	4.0	
circumference, C [m]	249.6	
rf freq., f_{rf} [MHz]	499.6	
hor / ver tunes, ν_x/ν_y	12.42 / 8.37	
dipole field, B [T]	0.168	0.873
hor size (at dipole), σ_x [mm]	< 1.8	< 0.3
ver size (at dipole), σ_y [mm]	< 1.8	< 0.10

In order to properly check the Booster synchrotron performance, the set of Diagnostics equipment described in Fig. 1 is installed in the machine. Next, we present the Diagnostics elements installed in the Booster and our experience during the pre-commissioning.

SCREEN MONITORS

The FSOTR is the acronym used to describe the setup that allows to insert either a Fluorescent Screen (YAG:Ce)
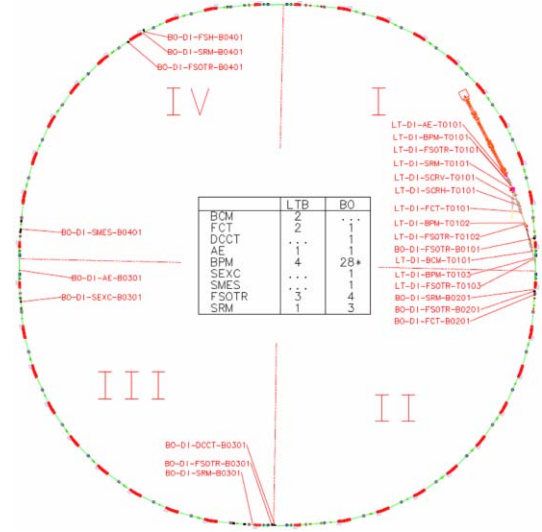
Figure 1: Linac, LTB, and Booster sketch with the location of the Diagnostics components.

or an Optical Transition Radiaton plate. The YAG screen is used for moderate intensity beams, the OTR is devoted for high intensity beams (which typically saturate the YAG emission). The setup includes a manually controled focus and zoom optics got *off-the-shelf* from EHD-Imaging and a Gigabit Ethernet CCD camera (Basler Scout, 12-bit resolution, 1034x779 pixels, with a square pixel size of $4.65\,\mu$m). More information about this setup is shown in [3].

We placed 3 FSOTRs to monitor the beam path along the transfer line from the Linac to Booster (LTB), while 4 more are installed in the Booster to ease the first commissioning goals (first injection, first quadrant, first turn).

In order to avoid undesirable image reflections with the YAG screen, it is convenient to make YAG plates optically non-transparent. We did so by attaching a sandblasted plate downstream the YAG. Moreover, reference marks have been added to this plate to provide in-situ calibration and centering position. Figure 2 shows an example of an image taken with the YAG screens.

BPM SYSTEM

The Booster is equipped with 44 hor and 28 ver correctors, and 44 button type BPMs. For economical reasons, it was decided to equip only 28 BPMs with the read out electronics (I-Tech Libera Brilliance). Simulations showed that the horizontal orbit correction with 28 BPMs allows an rms residual of 0.5 mm at BPMs, with a maximum of 4.5 mm
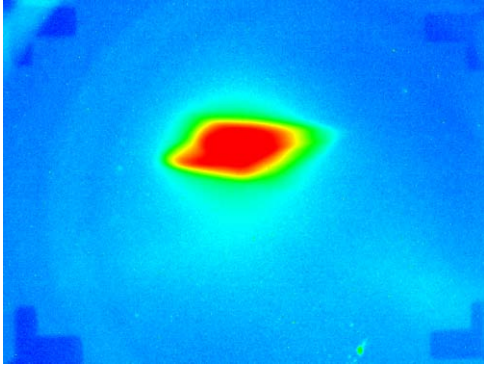
Figure 2: Example of a beam image at LTB transfer line with the YAG screen.

in the hor plane [4].

We found that the orbit correction was not efficient enough to correct the orbit on the horizontal plane, and orbits with ±4mm (at BPMs) in injection conditions were found (see Fig. 3). To improve the Booster commissioning efficiency, we are currently taking Libera electronics from the Storage Ring for all the existing Booster BPMs, so as to equip (at least temporaly) all the 44 BPMs with read-out electronics.

We typically used the Liberas on *Data on Demand Mode* (DD), which allows to obtain 200 ms of turn by turn data. Although the same trigger on all units is delivered by the ALBA timing system, data retrieval from all Libera units before the next trigger is not guaranteed. However, we did not find any trigger discrepancy. We have been using this mode to monitor the orbit along the ramp and perform tune measurements [5].
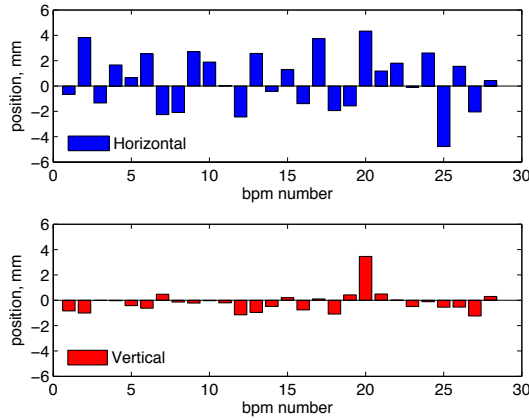

Figure 3: Example of a closed orbit measurement.

Orbit correction was performed using the *Slow Acquisition Mode* (SA), which performs an average on a 10 Hz period. Figure 3 shows an example of an orbit measurement in the hor and ver planes. A suspicious BPM (#20) was found to have too high vertical readings and higher XY coupling than the others. This BPM and its electronics are

currently under investigation. The accuracy for a 0.2 mA beam was ∼4 μm on SA mode and 70 μm in DD mode, which agrees with the previous studies [7].

Tune monitoring

Two stripline BPM are installed in the ALBA Booster for tune measurements. One of the striplines excites the beam around the tune frequency (referred to SEXC in Fig. 1), while the other is connected to the electronics that compute the tune measurement (referred to SMES in Fig. 1). Details about this system are throughly given in Ref. [5].

CURRENT MONITORS

Linac, LTB and Booster are equipped with three different type of current monitors: Fast Current Transformers (FCT), DC Current Transformers (DCCT) and Beam Charge Monitors (BCM). The only worth reporting problem in all cases is the noise produced by the nearby components such as klystrons or pulsed magnets.

The Linac beam pulse charge is precisely measured with the Beam Charge Monitors (BCM). These monitors are Bergoz *off-the-shelf* components, and as reported previously, we had to struggle the noise produced by the Linac klystrons [6].

We extensively use the in-flange Fast Current Transformer (FCT) along the Linac (6 units), and Linac to Booster transfer line (2). This allows to easily monitorize transmission efficiency along the transfer line by comparing the scope signals. We did not encounter major problems with them, except for the FCT at the Booster, which picks up the noise produced by the attached Booster injection kicker – see Fig. 4.

Figure 4: Scope signal with the 2 last FCTs on the transfer line (green and violet traces), kicker pulse (yellow) and the Booster FCT signal (pink trace). The Booster FCT baseline is significantly affected by the kicker pulse.

The most precise Booster current measure is done with the DCCT, whose specifications are ±1.7μA (rms, averaging over 1ms), with a temperature drift of 10μA / °C. Figure 5 shows the current offset drift along 48 hours. It oscil-

lates with an amplitude of 40μA, consistent with the temperature evolution measured on a quadrupole yoke (temperature oscillation amplitude of $3.3\,^{\circ}$C) and less consistent with the temperature logged in the tunnel.

During non-commissioning periods, the oscillation amplitude (no beam, tunnel open) increased to 50μA, which points towards a thermal effect. In any case, we plan to install a thermocouple at the DCCT to further study this effect.
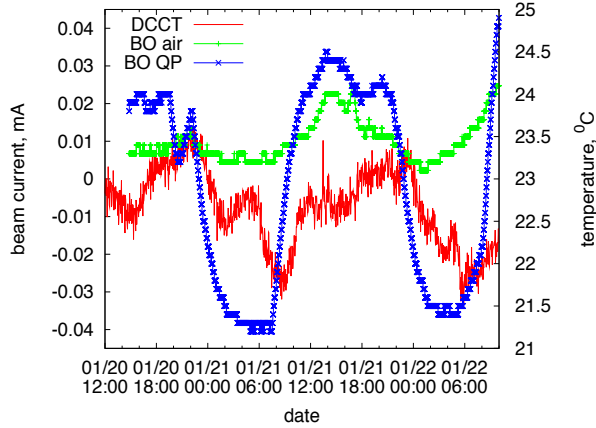

Figure 5: DCCT offset drift evolution during two days (red trace), and temperature evolution at a quadrupole yoke (blue trace) and tunnel ambient temperature (green).

SYNCHROTRON RADIATION MONITORS

The Synchrotron Radiation Monitors (SRM) infers the beam size using the synchrotron radiation produced when the beam traverses a bending magnet. The SRM setup includes optomechanics components from Thorlabs, a commercial telephoto lens (Sigma 70-300, with manual zoom and focus) and the CCD camera (same model as the FSOTR ones). These components are holded using ad-hoc mechanical supports designed in-house.

The fine image alignment is performed using the beam itself through an orientable mirror, which compensates all other mechanical misalignments through two position knobs, which is not an inmediate task: one needs several restricted tunnel accesses to move the knobs. This is not always possible during a commissioning period.

A peculiar SRM image is shown in Fig. 6, which shows two different spots. These spots slightly move when the upstream vertical corrector is powered to two different values: +0.05 A (left), and -0.05 A (right).

The reason for these two spots stems in the SRM design itself, which is limited by the available space. The SRM not only receives the radiation fan from the dipole where it is located, but also from the upstream dipole (5 m away). Therefore, we are having two images: one focused image (corresponding to the beam crossing the dipole where the SRM is located), and one unfocused image (corresponding to the upstream dipole).

The influence of the upstream dipole will be finally assessed during the next commissioning. In the other two SRM, the final image could not be evaluated because we did not have time to properly align the system.
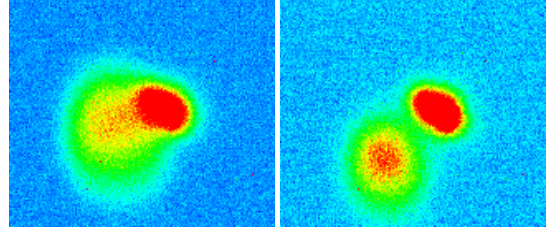

Figure 6: Images of the two beams with the SRM when the vertical corrector upstream the dipole is powered to +0.05 A (left), and -0.05 A (right).

SUMMARY

The set of diagnostics described in this report performed satisfactorily and allowed a successful Booster precommissioning. Nonetheless, few aspects are being addressed to improve the diagnostics performance.

We need to address the noise produced at the FCT by the nearby kicker. The DCCT is performing without worrying problems, and the 40μA oscillation drift is within the thermal specifications.

To improve the orbit correction, we are equipping all the 44 button BPMs with the read-out electronics for the next commissioning.

The SRM design provides two beam images in the CCD camera: one focused and one unfocused image due to the influence of the upstream dipole. Its influence will be finally assessed during the next commissioning.

ACKNOWLEDGMENTS

REFERENCES

[1] G. Benedetti, U. Iriso, and A. Olmos. *Beam measurements at the ALBA Linac*, Proc. of PAC09. Vancouver (Canada), 2009.

[2] G. Benedetti, D. Einfeld, Z. Marti, M. Munoz, M.Pont. *Optics for the ALBA Booster Synchrotron*, Proc. of EPAC08. Genoa (Italy), 2008.

[3] U. Iriso, G. Benedetti, and F. Pérez. *Experience with YAG and OTR screens at ALBA*, Proc. of DIPAC09, Basel (Switzerland), 2009.

[4] G. Benedetti. Closed orbit correction in the ALBA Booster, CELLS Tech. Note AAD-BO-BD-AN-0186, 2007.

[5] U. Iriso, F. Pérez and A. Salom. *Tune measurements at the ALBA Booster*, Proc. of BIW10, Santa Fe (USA), 2010.

[6] U. Iriso, F. Pérez and A. Olmos. *Beam diagnostics at the ALBA Linac*, Proc. of DIPAC09, Basel (Switzerland), 2009.

[7] A. Olmos, F. Pérez and T. Günzel. *BPM design for the ALBA Synchrotron*, Proc. of EPAC06, Edinburgh, Scotland (2006).